

Context for Today's Meeting

SWRCB is Developing Nutrient Objectives for California Waterbodies

- Completed nutrient numeric endpoint (NNE) framework for streams & lakes (EPA 2006)
- Conceptual approach and work plan drafted for NNE development in California estuaries (EPA 2008)
- In 2008, SWRCB staff initiated a project to develop NNE framework for estuaries
 - Scope of effort called for literature review and work plan specific for San Francisco Bay

Project Organization-SF Bay

SF Bay SAG

State Water
Resources
Control Board
(SWRCB)

SF RWQCB

STRTAG

SF Bay Technical Team

Science Advisory Board (SAB)

Developing NNE Workplan for SF Bay-Process

Science

- Form technical team
- Review literature on use of NNE candidate indicators in SF Bay
- Identify "promising" indicators, data gaps and recommended next steps

<u>Stakeholders</u>

- Form SF Bay SAG
- Review NNE framework & background documents
- Provide feedback on literature review, data gaps and prioritize next steps







NNE Workplan for SF Bay

Timeframe for Literature Review

SF Bay Tech Team SF Bay SAG ✓ Form technical team Oct 2010 Form SF Bay SAG Review conceptual Dec 2010 approach and identify candidate indicators Jan 2011 Review background docs Complete lit. review, Feb 2011 data gaps & next steps Comment on lit. review Mar 2011 Finalize lit. review

Meeting Goals

- Revisit SF Bay SAG membership
 - Additional members?
- Discuss and provide feedback on broad conceptual approach to development of nutrient water quality objectives
- Process to develop NNE framework for SF Bay
 - Recommendations from SF Bay Tech Team (Dec 2010 mtg)

SF Bay SAG: Groups

- Municipal dischargers
 - Bay/ Delta and by region of the Bay
- Industrial/refineries
- Agriculture
- Environmental
- Land owners/managers
- South Bay Salt Pond Restoration (CC/UFWS)
- Commercial and recreational fisheries

California's Approach to Nutrient Objectives: Nutrient Numeric Endpoint Framework

SWRCB Staff Strategy: Narrative objectives with numeric guidance (coined as "NNE") to interpret narrative objectives

- Narrative objectives promulgated once
- Numeric guidance can change as science evolves, collectively referred to as the "nutrient numeric endpoint" (NNE) framework

Nutrient Objectives Are Scientifically Challenging

- Nutrients are required to support life
 - How much is too much?
- Toxicity is rarely the endpoint of interest
 - Adverse effects occur at much lower levels
- Using ambient concentrations can give false positives or negatives



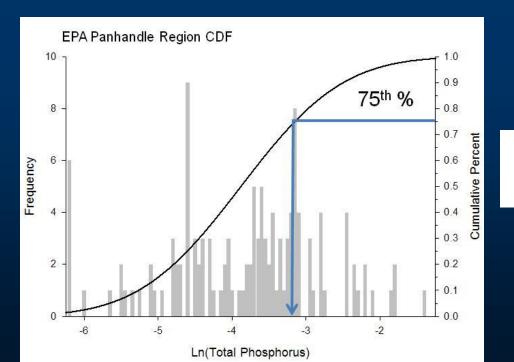
Three Basic Approaches to Nutrient Objectives

EPA guidance on nutrient criteria development suggests three basic approaches (EPA 2001)

- Reference
- Empirical stress-response models
- Mechanistic cause-effect models

Reference Approach

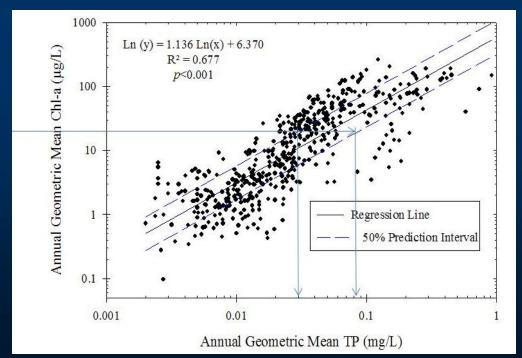
- Characterize distributions of nutrient in "minimally disturbed" waterbodies
- Choose <u>nutrient concentrations</u> at some statistical percentile of reference waterbodies



75th Percentile of Florida Panhandle Reference Streams

Empirical Stress-Response Approach

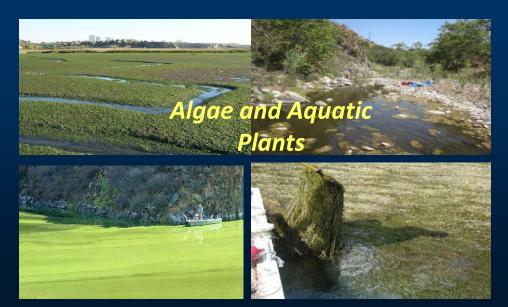
- Identify biological response indicator of interest (e.g. algal biomass)
- Analyze statistical relationships between <u>nutrient</u> <u>concentrations</u> and response

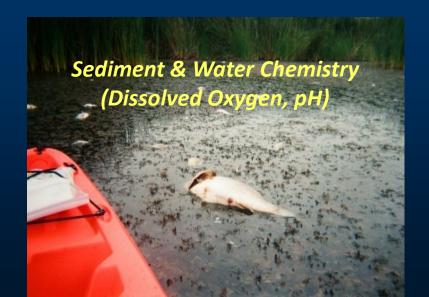


Correlation Between Chl <u>a</u> and TP in Alkaline Lakes

Cause – Effect Approach

- Diagnosis based on response indicators
 - Cause-effect relationships between response indicators and beneficial uses
- Need mechanistic models to link response indicators to nutrients
 - Nutrient loads rather than ambient concentration





NNE Based on Cause-Effect Approach

- Cause effect approach has several advantages
 - Direct linkage with beneficial uses
 - More precise diagnosis of adverse effects
- Other approaches are problematic
 - Reference sites are unavailable for many waterbody types, particularly estuaries
 - Empirical stress-response is data intensive and statistical relationships can be spurious, or have lots of unexplained variability

Tenets of California's Approach

- Diagnosis based on <u>response indicators</u>
 - Assessing eutrophication, not nutrient overenrichment
 - More direct linkage to beneficial use
 - More integrative measure than nutrient concentrations

A. Increased Nutrient/Organic Matter Loads, and/or Altered N:P:Si Ratios

B. Ecological Response

Primary Producers

Water/Sediment Chemistry

Consumers (Invertebrates, Birds, Fish, Mammals)

C. Co-Factors, e.g.:

Hydraulic Residence Time
Climate
Suspended Sediment
Stratification
Estuarine circulation
Hyposgraphy
Top-down grazing
Denitrification

Ecosystem Services and Beneficial Uses

Ecological Services Beneficial Uses

Habitat, Food for Birds, Fish, Invertebrates, and Mammals	EST, MAR, WILD		
rotection of Biodiversity, Spawning,	SPWN, MIGR, RARE		

Production of Commercial Recreational COMM, SHELL, AQUA Fish and Invertebrates

Human Services

Aesthetics, Odor	REC2
Good Water Quality, Taste	REC1

Conceptual Model: Linking Nutrients, Ecological Response, & Beneficial Uses

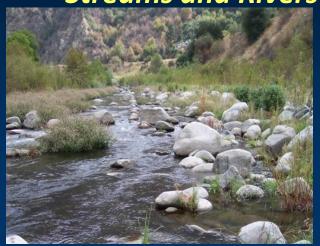
Co-factors modulate ecological response

Three Tenets of California's Approach to Nutrient Objectives

- Diagnosis based on response indicators
 - More direct link to beneficial use
 - More integrative measure than nutrient concentrations
- Multiple lines of evidence
 - More robust diagnosis
- Need models to link response indicators to nutrients
 - Nutrient loads rather than ambient concentration

Indicators Will Vary By Aquatic Habitat

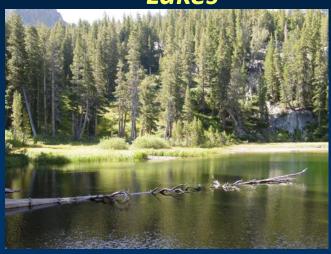
Streams and Rivers



Estuaries



Lakes



Ocean



Stream NNE: Example of 303(d) Algal Biomass Thresholds by Beneficial Use



Benthic Algal Biomass

νН

pH

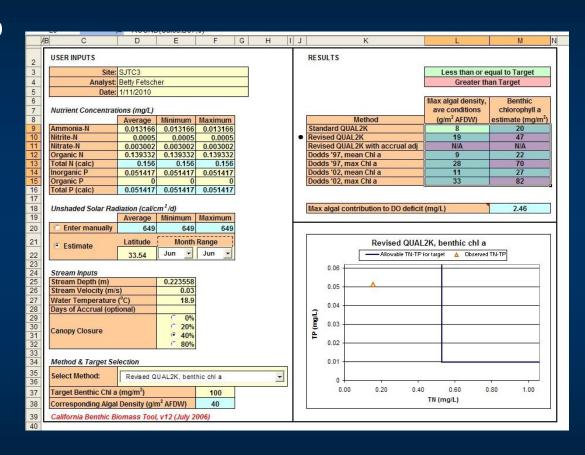
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Dissolved Oxygen

Response Indicator	Beneficial Use					
	COLD	WARM	REC-1 &-2	MUN	SPWN	MIGR
Benthic Algal Biomass (mg chl <u>a</u> m ⁻²)	150	200	Same as WARM/COLD	100	100	Not Defined

NNE Benthic Biomass Spreadsheet Tool

- Spreadsheet tools to convert response targets to sitespecific TN and TP concentration goals
- Account for cofactors that modify biological response to nutrients



 Used for initial screening – defer to more complete modeling / monitoring studies

Status of Nutrient Objective Development by Waterbody Type

Waterbody Type	Status
Streams	Endpoints and tools drafted
Lakes	Endpoints and tools drafted
Enclosed Bays & Estuaries	Endpoints under development
Nearshore Coastal Waters	No work undertaken

Take Home Message

NNE "framework" consists of two components:

- Numeric endpoints based on <u>ecological response</u>
- Requires models to link <u>ecological response</u> indicators back to nutrients and other co-factors controlling eutrophication or oligotrophication

NNE assesses "eutrophication" or "oligotrophication", not nutrient overenrichment

Feedback on NNE Conceptual Approach

Questions? Comments?

Process to Develop NNE Framework for SF Bay

- Specify geographic scope and habitat types included
- Develop conceptual models and ID candidate indicators
- Review utility of indicators vis-à-vis evaluation criteria
- Identify data gaps and recommended next steps to:
 - Develop diagnostic framework and select endpoints
 - Develop load-response models
- Work plan Consensus on prioritized steps to develop NNE

SF Bay Technical Team Roster

- Rafael Kudela (UC Santa Cruz)
- Jim Cloern (USGS)
- Kathy Boyer (SFSU)
- Dick Dugdale (SFSU)
- Lester McKee (SFEI)
- Martha Sutula (SCCWRP)

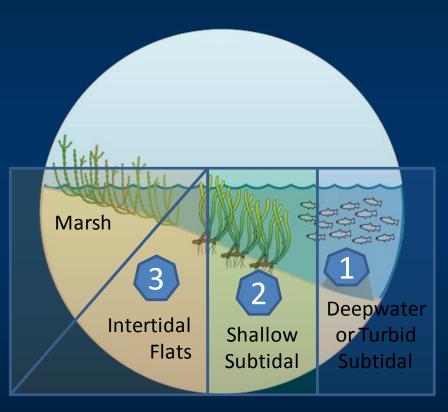
Recommended Geographic Scope of SF Bay Literature Review and Initial NNE Development



Scope synonymous with SFRWQCB boundary

- Represents transition in hydrology & salinity regime
- Natural boundary for development of hydrodynamic and water quality models

Recommended Habitat Types To Include in SF Bay NNE Framework



- Include intertidal flats, shallow and deepwater subtidal
- Exclude emergent marsh
- Include estuarine diked baylands and restored salt ponds

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 NNE

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B. Ecological Response

Primary Producers

Water/Sediment Chemistry

Consumers (Invertebrates, Birds, Fish, Mammals)

C. Co-Factors, e.g.:

Hydraulic Residence Time Climate Suspended Sediment Stratification Estuarine circulation Hyposgraphy Top-down grazing Denitrification

Ecosystem Services and Beneficial Uses

Ecological Services Beneficial Uses

Habitat, Food for Birds, Fish, Invertebrates, and Mammals	EST, MAR, WILD		
Protection of Biodiversity, Spawning,	SPWN, MIGR, RARE		
Migration and Threatened/Rare Species	,,		

COMM, SHELL, AQUA Production of Commercial Recreational Fish and Invertebrates

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Conceptual Model: Linking Nutrients, **Ecological** Response, & Beneficial Uses

Co-factors modulate ecological response

SF Bay Estuarine NNE Framework: Candidate Indicators

Primary Producers Indicators

- Phytoplankton
- Macroalgae
- Submerged aquatic vegetation

Physiochemical Indicators

- Dissolved oxygen
- Light attenuation
- Toxic metabolites (HAB toxins)
- Urea
- Ammonia: nitrate ratio

Consumer Indicators

- Benthic macroinvertebrates
- Jellyfish

List of Candidate NNE Indicators For SF Bay by Habitat Type

Indicator	Habitat Type			
	Tidal	Subtidal	Seagrass/	Deepwater
	Flats	Unvegetat	brackish	/turbid
		ed	SAV	subtidal
Dissolved oxygen				$\sqrt{}$
Macroalgae biomass/% Cover			$\sqrt{}$	
Epiphyte load & light attenuation			$\sqrt{}$	
Phytoplankton biomass, community				$\sqrt{}$
composition and/or growth efficiency				
HAB sp. abundance and/or toxin conc.				$\sqrt{}$
Macrobenthos taxonomy/ biomass				$\sqrt{}$
Ammonia:nitrate ratios, urea			$\sqrt{}$	$\sqrt{}$
Jelly fish			√	

Process to Develop NNE Framework for SF Bay

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Indicator Review Criteria

- Clear understanding of how indicator changes along disturbance gradient (pristine to most disturbed)
- Dose response relationship exists between indicator & higher trophic level (link to beneficial use)
- Can develop <u>predictive model</u> between nutrient loads, other cofactors, and ecological response (statistical, spreadsheet, or dynamic simulation models)
- Scientifically sound and practical measurement process
- Show a detectable trend in eutrophication or oligotrophication (signal: noise ratio is acceptable)

SF Bay Literature Review- Outline

- Introduction and purpose
- Conceptual models, beneficial uses, list of candidate indicators, & indicator review criteria
- Geographic setting
- Trends and data gaps in estimation of nutrient loads in SF Bay
- Evaluation of Candidate NNE Indicators for Use in SF Bay
- Synthesis, data gaps, and recommended next steps

Status of Literature Review

- Draft complete
- Initial review by SF Bay Tech Team on Feb 11, 2011
- Final draft targeted for March 2011 for distribution to SF Bay SAG

Process to Develop NNE Framework for SF Bay

- ✓ Specify geographic scope and habitat types included
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Discussion on Development of Workplan

Coordination on development of RMP nutrient strategy

Wrap Up and Next Steps

- Next SF Bay SAG Meeting
 - Late March or early April
- Coordination with RMP nutrient strategy

Review of Science for NNE in Estuaries: Example for Mudflat Habitat

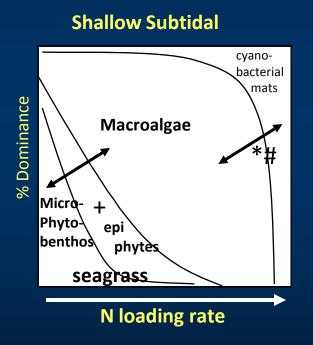


Macroalgal Mats in Mugu Lagoon, Southern California (Photo Credit L. Green)

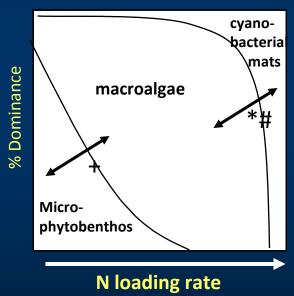
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Conceptual model of relationships among N-loading rate and the community composition of primary producers in shallow subtidal and intertidal flats of <u>perennially</u> tidal estuaries (Adapted from Valiela et al. 1997)

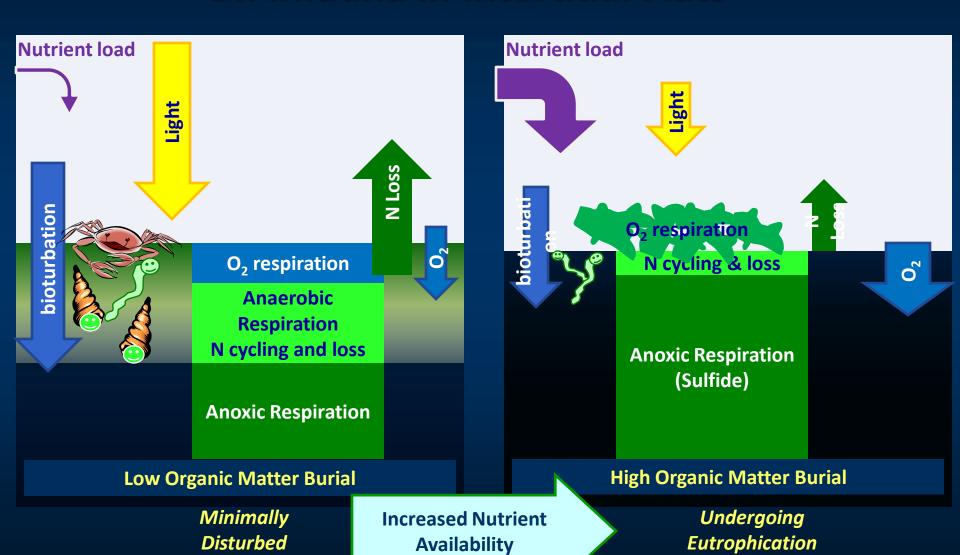


Unvegetated Intertidal



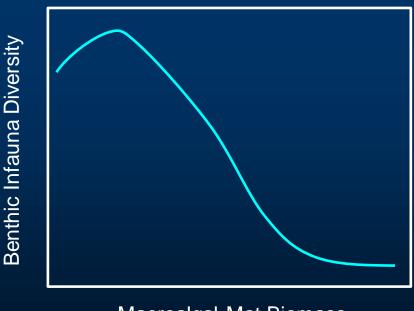
- * depends on tidal elevation and water residence time
- + mediated by herbivory
- # depends on benthic topography

Conceptual Model of Effects of Macroalgae On Infauna in Intertidal Flats



Documented Link with Beneficial Uses: Two Tests

- Weight of scientific evidence demonstrating linkage?
- Dose-response data that support selection of a threshold?



Macroalgal Mat Biomass

Effects on Management Endpoints of Concern

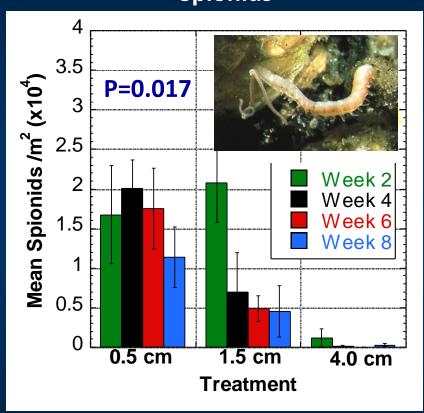
- Poor surface water quality (strong diel DO fluctuations and hypoxia, increased bacterial growth) and aesthetics: REC1, REC2, EST, MAR, SPWN, RARE, COMM
- Poor benthic habitat quality (Increased sediment organic matter accumulation, increased pore water sulfide, ammonia, etc.): EST, MAR, RARE, COMM, AQUA
- Changes in food web (shifts in food supply for upper trophic levels)
- Loss of critical habitat for fisheries, birds, esp. T&E species

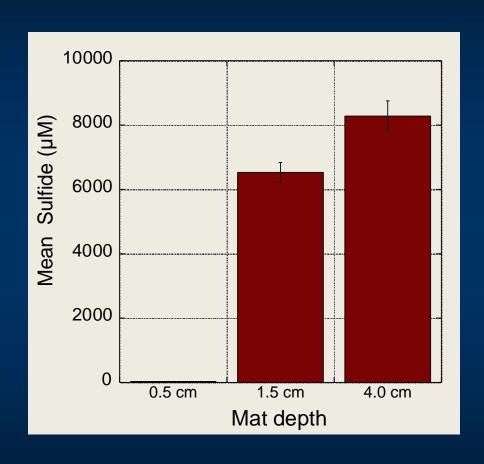
Summary of Studies Documenting Effects of Macroalgae on Infauna on Intertidal Flats

- Lots of studies demonstrating effects
- Comparison difficult because of disparate methods
- Studies cannot be used to evaluate thresholds, with exception of:
 - Green 2010 (Mugu Lagoon, so. Calif.)
 - Bona et al. 2006 (European Mediterranean)

Macroalgal Blooms on Intertidal Flats Cause Declines in Benthic Infauna Diversity and Abundance

Spionids





Lauri Green, Ph.D. Dissertation, UCLA Department of Biology (Spring 2010)

Macroalgal Blooms Reduce in Availability of Invertebrate Forage Food for Birds and Fish



Indicators of Macroalgal community structure

Abundance–Scientifically well-vetted means of measuring

- Biomass (thickness)
- Percent cover

Taxonomic composition

not relevant for California estuaries

Macroalgae Has A Well-Documented Relationship with Nutrient Loading

- Yes best example is Waquoit Bay (MA)
 - Total nutrient loads predict algal biomass in 3 subbasins with differing loads
 - But the relationship is complex (easiest where river sources are dominant)
- Data to establish empirical load-macroalgal response relationships for California estuaries do not exist
- Few examples of use dynamic simulation modeling exist, none local

Information Needs to Be Synthesized into an Assessment Framework

Example of Macroalgal Assessment Framework From EU WDR (from Scalan et al. 2007)

ALGAL BIOMASS	>3000 g m²	MODERATE	POOR		BAD			
	>1000 to 3000 g m²	GOOD/MODERATE entrained algae - monitor	MODERATE	MODERATE/POOR entrained algae - monitor	POOR		BAD	
	500 to <1000 g m²	GOOD	GOOD/MODERATE entrained algae - monitor		MODERATE		POOR	POOR
	100 to <500 g m ⁻²	HIGH/GOOD entrained algae - monitor	GOOD		GOOD no entrained algae no monitoring	GOOD/MODERATE entrained algae - monitor	MODERATE	MODERATE/POOR entrained algae - monitor
	<100 g m²	HIGH					GOOD/MODERATE entrained algae - monitor	MODERATE
		=5%</td <td colspan="2">>5 to 15%</td> <td colspan="2">>15 to 25%</td> <td>>25 to 75%</td> <td>>75 to 100%</td>	>5 to 15%		>15 to 25%		>25 to 75%	>75 to 100%
	1	% COVER						

Macroalgae on Intertidal Flats: Summary

- Macroalgae meets criteria as "acceptable" indicator
- Additional data on effects of macroalgal mats on infauna in intertidal flats
 - Need various treatment levels and duration
 - Response may vary by sediment type and organic matter content, time of year, estuarine class, climate, etc.
- Lack of information on range of biomass and % cover found over disturbance gradient in California estuaries
- Lack of information on precision and accuracy of nutrient load-response models

Comments? Questions?

Developing NNE Workplan for SF Bay-Process

Science

- Form technical team
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- Identify "promising" indicators, data gaps and recommended next steps

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NNE Workplan for SF Bay

Geographic Scope of SF Bay Literature Review and Initial NNE Development



Timeframe for Effort

SF Bay Tech Team

SF Bay SAG

Form technical team

Sept 2010

Form SF Bay SAG

Nov 2010

Review background docs

Complete lit. review,

data gaps & next steps

Jan 2011

Draft work plan

Mar 2012

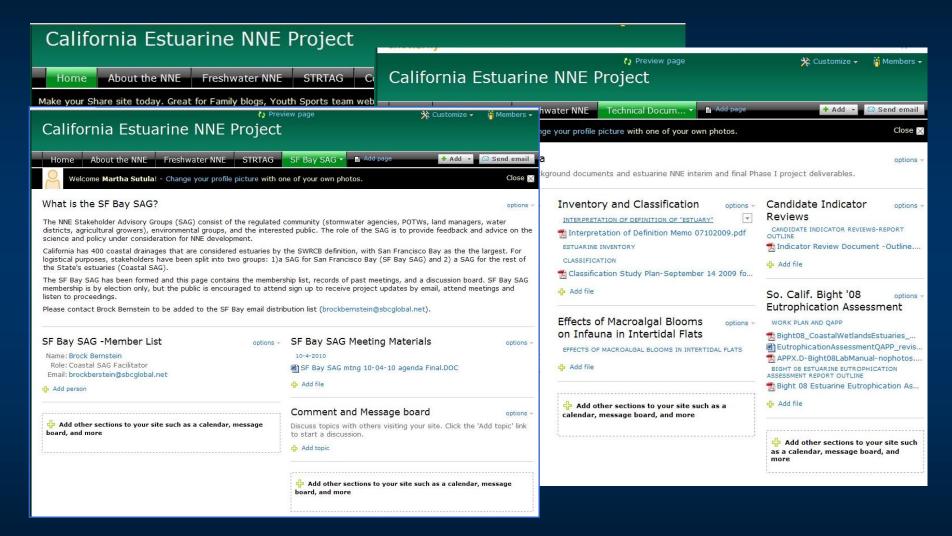
Comment on lit. review

Final work plan

May 2012

Comment on draft work plan

Clearinghouse for NNE Documents



http://californiaestuarinenneproject.shutterfly.com/

Questions? Comments?

Agenda

- Welcome, introductions, meeting goals, logistics
- Overview of NNE project, organization and key staff
- NNE conceptual approach and workplan development for San Francisco Bay
- Role and selection of San Francisco Bay stakeholder advisory group members and alternates (SF Bay SAG)
- Summary of action items, next steps

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- Commercial and recreational fisheries

Action Items, Next Steps

- Confirm members and alternates
- Set date for first SF Bay SAG meeting- November